DOCUMENT RESUME

ED 320 892 SP 032 447

AUTHOR Osness, Wayne H.; Hiebert, Lujean M.
TITLE Measures of Strength and Fitness for Older Populations.
PUB DATE Apr 90
NOTE 32p.; Paper presented at the Annual Meeting of the American Alliance for Health, Physical Education, Recreation and Dance (New Orleans, LA, March 28-31, 1990).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Aging (Individuals); Body Composition; *Muscular Strength; *Muscular System; *Older Adults; *Physical Fitness; Physiology; Testing

ABSTRACT

The overall strength of the musculature does not require testing of large numbers of muscle groups and can be accomplished from three or four tests. Small batteries of strength tests have been devised to predict total strength. The best combination of tests for males are thigh flexors, leg extensors, arm flexors, and pectoralis major. The battery for females consists of measuring thigh flexors, thigh extensors, leg extensors, pectoralis major, deltoids, and hand flexors. The hand grip test is a reasonable representation of total strength. This paper discusses the effectiveness of these tests in measuring the decline of muscular strength in older adults. Appendices provide figures displaying mean scores of various fitness tests and information on strength tests used as predictors of total body strength. (JD)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED320892

MEASURES OF STRENGTH AND FITNESS FOR OLDER POPULATIONS

Presented at AAHPERD National Convention - 1990

Wayne H. Osness

Lujean M. Hiebert

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Wayne H. Osness

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

SP032447

BEST COPY AVAILABLE

Measures of Strength and Fitness for Older Populations

Presented at AAHPERD National Convention - 1990

by: Wayne H. Osness, Ph.D.
Lujean M. Hiebert, M.S.
University of Kansas

I. Strength as a Function of Age

It has been well established that strength varies with age. There is little gender difference in children up to the age of ten, after this age, muscle strength increases much faster in boys than in girls (22). However, both sexes reach maximal muscle strength between twenty and thirty years of age (40). Some studies have shown strength to begin a decline immediately after 30 (22, 32, 40) while other studies have shown a plateauing until 60 and then a decline in strength (7, 27). Regardless, strength is less than maximal after a person reaches sixty. DeVries (14) determined the loss of strength after 60 years not to exceed 10-20%. Rodahl (40) and Hettinger (22) reported that after age 65 a male has 80% the muscle strength of a male between 20 and 30.

Jette (25) conducted a longitudinal study involving men 35-72 years old. Subjects were divided into three groups: (1) regular exercisers, (2) irregular exercisers, and (3) non-exercisers, and tested for hand grip and back and leg strength. The subjects were tested with an average of eight years between tests. All showed appreciable decreases with age. However, the subjects that had been exercising lost the least amount of strength (5.4 pounds). The irregular exercis-

SP 032 447

ers lost 8.7 pounds of strength and the non-exercisers lost 9.1 pounds.

The literature on females indicates a similar pattern. Strength scores increase regularly from 9 to 19 years, more slowly to 30 years of age, and then begin a decrease (32). The strength scores among females have been found to be less than those of males regardless of age. The difference is found to be greater in the trunk, arms and shoulders than in the legs (32, 46). The average values are approximately two-thirds that of men (22). If strength is expressed per unit of cross-sectional area, differences due to sex are revealed to be very small (14, 24).

The decline in strength for either sex is not found to occur at the same rate. A study by Rejs as reported by Simonsen (43), showed the strength of the back muscles dropped faster with age than the strength of arm and hand muscles. Data collected by Ufland as reported in the same publication (43), revealed that between the ages of 30 and 39, the strength of the back muscles reverted back to their value at the age of 20. This same drop occurred, but between the ages of 40 and 49 in the biceps and between 50 and 59 years in hand grip strength. Hand grip strength appears to decline most slowly. These findings have been reproduced by Petrofsky and Lind (38). They measured hand grip strength of men aged 22 to 62 years, all employed at the same machine shop. They found little change in grip strength or endurance due to age.

Data collected over a ten year period at the University of Kansas (36) has demonstrated a continual decline from age

30 to age 90 with a more rapid decline after age 70 years (Figure 1) in a clinically tested population of over eight thousand subjects. The same is true with hand steadiness (Figure 2), reaction time (Figure 3), choice response time (Figure 4), and hand-eye coordination (Figure 5) (36). This finding is supported by Grimby (19) who noted the same change in the decline at about 70 years of age.

Various theories have been purported to explain why strength decreases with age (15, 20, 27, 40, 48). Rodahl (40) and Wessel (48) found the decrease in strength was not as much a matter of age but rather the decrease in habitual activity. The loss in muscular measurements was due to the "atrophy of disuse". Erimini (15) reported a reduction in respiratory capacity accounting for losses in muscular endurance and capacity for recovery.

In muscle biopsies of the vastus lateralis muscle of 51 volunteers aged 20-76, Larsson et al. (27) reported a lower percentage of Type II fibers with age. Isometric and dynamic strength measurements of knee extension in these same subjects showed a significant correlation between the decrease in strength with age and the decline in Type II fiber area. These changes were found without any measurable external change in muscle atrophy. This might be accounted for by replacement of muscle by fat and connective tissue (1, 17).

Grimby et al. (18) and Aniansson (3) measured fiber areas of the vastus lateralis and biceps brachii of subjects aged 78-81. Their results also revealed a decline in fast twitch

area. However, the decline was greater in the vastus lateralis muscle than the biceps brachii. This is in agreement with a less pronounced reduction in strength with age in the upper extremity than in the lower (5).

Gutmann and Hanzlikova (20) have studied the total number of muscle fibers in the soleus muscle of four-month-old and two year-old rats. They reported a decrease from 2357 $\pm$ 78 muscle fibers in the young rats to 1758 $\pm$ 39 fibers in the old rats. Although there was a large reduction in muscle fibers, they found only a small decrease in motor neurons (120 $\pm$ 3.8 to 115 $\pm$ 2.31). The number of alpha motor fibers was 35 in the old rats and 32 in the younger rats. They concluded from this that since there was no loss of motor nerve cells in the spinal cord, the reduction in total number of muscle fibers was due to terminal random degeneration of endplates. Bruce (8) demonstrated that atrophy alone is not the cause of the weakness of old age by comparing voluntary force measurements with normalized cross-sectional area.

II. Isometric Versus Isokenetic Evaluation

Isometric strength tests have been used for several hundred years. To date, they have been used in assessing muscle strength of hospital patients and classifying student's athletic abilities. Total strength has been predicted from a single isometric test such as the handgrip dynamometer or predicted for a battery of tests. Throughout this time, isometric measurements have been considered a reliable and

valid tool for measuring strength.

Isometric measurements have been reported to be related to anthropometric values (6, 39, 45). In these studies, involving healthy adult males, hand grip strength was found to be significantly related to weight but only indirectly related to height (45).

The angle of pull or the joint angle plays an important role in determining the amount of force that can be generated in an isometric or static contraction. Studies measuring knee extension reveal the largest values are obtained between 50-75 degrees of knee flexion (2, 9, 21, 28, 34) and decrease significantly as the knee approaches extension (11). Subjects in these studies ranged in age from 18 to 70 years of age. Reliability coefficients between .970 and .998 were reported in Campney and Wehr's (11) study involving knee extension.

Moudgill and Karpovich (33) investigated the maximum force exerted by forearm flexors in nine subjects aged 23-44 years. They measured the force at 60, 100, and 120 degrees and discovered the greatest values were obtained at 100 degrees.

Clarke, Bailey, and Shaw (13) revealed that the values for hip flexion varied according to the test position. The values were greater when the subject lay supine than when the subject was seated with his/her knees flexed over the edge of a table.

Age has also been shown to play a role in determining isometric strength values (10, 31). Burke et al. (10) found hand grip strength, in subjects aged 12-79 years old, rapidly

increases in ages 12-25. After that there was a gradual decline up to and through the 75-79 year old group. This agrees with Montoye and Lamphiear (31) who reported maximum grip strength to be achieved in the mid 20's and decline gradually, thereafter. Burke et al. (10) also determined that grip strength in the 75-79 year old group was approximately equal to that of 12-15 year olds. In their study the 65-69 year age group had a hand grip strength of 48 pounds as compared to 63 pounds for the 20-24 year olds and 61 pounds for the 25-29 year olds. This work supported Rodahl (40) and Hettinger (22) who both reported that after age 65 a man has 80% of the muscular strength of a man between 20 and 30.

Studies of isokinetic muscle contraction have examined many of the same parameters as those which have been studied for isometric contractions, i.e., predictive capabilities, angle for peak torque, and effect of aging. Aniansson et al. (2) studied the various activities of daily living in 70 year old men and women. They discovered a significant correlation between walking speed and the peak values of isokinetic strength in the right quadriceps of healthy women, but not of men.

Several researchers have looked at the relationship of torque to the velocity of the joint movement (2, 30, 44). Thorstensson et al. (44), in their study of 25 male subjects aged 17-37, found peak torque gradually declined with increasing velocities of shortening. They reported a 45% decrease in peak torque with measurements made at 180 /sec to 30 /sec in

70-year-old subjects.

It has also been reported that by changing velocity a change in the angle at which peak torque is applied will occur. Thorstensson et al. (44) found that peak torque values occurred at more extended knee positions when the velocity increased. Values ranged from 66.2 ± 1.7 degrees at 15 /sec to 54.7 ± 1.5 degrees at 180 /sec. Osternig (37) measured knee velocities ranging between 5 and 25 RPM and discovered peak torque decreased from 85 to 50 degrees when velocity increased. These studies agree with Moffroid et al. (30), who claimed that at increasing velocities the knee joint can often pass by the point of optimal performance by the time the contractile component attains maximum tension.

Neurologically speaking, there is little basis for the belief that differences should occur among maximum isometric and isokinetic muscle contractions if joint angle and time are held constant, but they do (41). In an EMG study done by Rosentsweig and Hinson (41) on the biceps brachii they found that muscle action potential was significantly different between isometric and isokinetic contractions. They found the larger muscle action potential occurred with isokinetic contractions.

Studies comparing torque values at the same joint angle revealed opposite results from the above study. These studies (27, 42) showed that isometric values were greater than isokinetic, but that the differences decreased as velocity of contraction decreased or if measurements were made towards the shortened muscle position.

Murray et al. (35) compared isometric values of knee extension at 30, 45, and 60 degrees to isokinetic values at these same angles while moving at 36°/sec. In subjects aged 20-86 years old, they found isokinetic torque to be significantly less with the larger differences occurring in the more flexed positions. This disagrees somewhat with Scudder (42) who found that the difference between isokinetic and isometric knee extension output increased as the muscle moved toward the shortened position or became more extended.

The difference between isometric and isokinetic torque values is also dependent on the velocity of the isokinetic movement (27, 42). The slower the velocity, the less the difference. Scudder (42) found in a measure of knee extension, that the average maximal isokinetic torques as compared to maximal isometric torques were 81.2% at 3 RPM and 66.6% at 15 RPM. In his study the standard error of measurement was $\pm$ 0.9 kg-m or less.

Knapic (26), in a study measuring isometric and isokinetic torque values for elbow flexion and extension and knee flexion and extension in male soldiers, found that closely adjacent isokinetic velocities were related in most cases (reliability coefficients greater than 0.90). He also concluded that torque elicited at low-velocity isokinetic contractions can be predictive of torque elicited during isometric contractions. Asmusson et al. (4) found a correlation of 0.80 between isometric forces and low-velocity isokinetic force in the elbow flexors of both athletes and non-athletes. Aniansson et al.

(2) found in 70 year old subjects that isokinetic peak torque values for knee extension 30, 60, 90, and 180°/sec were significantly correlated with maximal isometric values ($p > 0.001$, $r = 0.59\text{-}0.95$).

III. Strength Tests That Predict Total Body Strength

The overall strength of the musculature does not require testing of large numbers of muscle groups but can be accomplished from three or four tests (12). Because of this, small batteries of strength tests have been devised to predict total strength (6, 29, 47).

Wendler (47) developed a battery of strength tests based on testing 47 different muscle groups with the universal dynamometer. The sum of the individual tests comprised the subject's total strength. The results of the study suggested a different battery for males and females. A correlation of .933 with total strength was possible in males from a battery of four tests. These tests consisted of measuring the thigh flexors, leg extensors, arm flexors, and pectoralis major. A battery of six tests for women correlated .938. These tests were thigh flexors, thigh extensors, leg extensors, deltoids, pectoralis major, and hand flexors.

Martin and Rich (29) used a battery of tests that required testing both left and right sides. The subjects were adult males and 22 pairs of muscle groups were measured by a dynamometer. The battery of tests used consisted of five pairs of muscle groups. The tests were pectorals, wrist

flexors, forearm flexors, thigh adductors, and thigh abductors. The correlation between the short battery and the complete test was .94. The correlation remained the same with the wrist flexors removed, but the researchers believed this test was important in testing at industrial plants.

As a single predictor of total strength, the hand grip test was reported to be a reasonable measurement (16). Heibert (23) supported this finding in a study of 60 to 75 year olds reporting correlation of .91 between grip strength and total arm strength, .80 with total leg strength, and .86 with total body strength using isokinetic values (table I).

As predictors of total arm, leg, and body strength, Hiebert (23) found that the best model consisted of measuring hand grip, hip flexion, and knee extension. This model accounted for 86% of the variability in the leg score; and 83% of the variability in the total body score (table II). Using two field tests as predictors was nearly as accurate as three tests. Also, two different combinations (hand grip/hip flexion and hand grip/knee extension) could be used for predicting isokinetic scores. The best single predictor was the hand grip test. It accounted for 83% of the variability in arm strength (table III), 65% in leg strength and 73% in total body strength.

IV. Summary

Studies have shown that strength varies according to the age of the subject (7, 22, 27, 32, 40). Maximum strength in

both males and females is reached between the ages of 20 and 30 years and then declines. By the time an adult reaches 60, his/her strength is approximately 20% of his/her maximum (22, 40). Simonsen (43) reported that back strength decreases faster than either the arm or hand muscles. Several theories (15, 20, 27, 40, 48) have been purported to explain this decrease. They include atrophy due to decreased activity, loss of contractile elements, and a lower percentage of Type II fibers. Isometric strength has been found to be significantly related to weight (6, 39).

Grip strength for 65-69 year olds was found to be approximately 80% that of 20-30 year olds (10, 22, 40). However, an 80% decrease is found in isometric knee extension measurements when comparing 70-86 year olds to 20-35 year olds (35).

The angle of pull plays an important role in determining the amount of force that can be generated in an isometric contraction. The largest values for knee extension occur between 50 and 75 degrees (2, 9, 21, 28, 39). Elbow flexion is found to be greatest at 100 degrees as opposed to either 60 or 120 degrees (33). Hip flexion is greater with the hip extended rather than flexed (13).

Isokinetic torque decreases with increasing velocity (2, 4, 44). The angle at which peak torque occurs also changes. A more extended or shortened position shows a decrease in strength. Isokinetic values are also affected by age. Results reveal torque increases to about age 30, remains constant in the middle ages, and then begins decreasing in the older age groups (44). The change is muscle group specific.

Comparisons between isometric and isokinetic values revealed greater muscle action potential with isokinetic contractions (41). Torque comparisons made at similar angles showed greater torque with isometric contractions, but the difference decreased as the velocity decreased (29, 35, 42). The results were the same in both young and old subjects. Several researchers reported high correlations between isokinetic and isometric values (2, 4) and felt low-velocity isokinetic torque values could be predictive of isometric torque.

Small batteries of strength tests have been developed to predict total strength (29, 47). Wendler (47) determined the best combination of tests for males to be thigh flexors, leg extensors, arm flexors, and pectoralis major. The battery for females consisted of measuring thigh flexors, thigh extensors, leg extensors, pectoralis major, deltoids, and hand flexors. These batteries correlated .93 and .93, respectively, with total strength. Martin and Rich (29) developed a correlation of .94 for adult males with a combination of pectorals, wrist flexors, forearm flexors, thigh adductors and thigh abductors using both left and right sides of the body. If only one test is used as a predictor of total strength, the hand grip test is a reasonable representation (16, 23).

References

1. Allen, T.H., Anderson, E.C., & Langham, W.H. Total body potassium and gross body composition in relation to age. J. Gerontol., 15:348-357, 1960.

2. Aniansson, A., Grimby, G., & Rundgren, A. Isometric and isokinetic quadriceps muscle strength in 70 year old men and women. Scand. J. Rehab. Med., 12:161-168, 1980.

3. Aniansson, A., Hedberg, M., Henning, G., Grimby, G. Muscle Morphology, Enzymatic Activity and Muscular Strength in Elderly Men. Muscle and Nerve, 9 (7): 585-591, 1986.

4. Asmussen, E., Hansen, D., & Lammert, O. The relation between isometric and dynamic muscle strength in men. In: Communications from the Testing & Observation Institute of the Danish National Association for Infantile Paralysis, Asmussen, E., Fredsted, A., Ryge, E. (eds). No. 11, 1961.

5. Asmussen, E. & Heeboll-Nielson, K. Isometric muscle strength of adult men and women. In: Communications from the Testing & Observation Institute of the Danish National Association for Infantile paralysis, Asmussen, E., Fredsted, A., Ryge, E. (eds.). No. 11, 1961.

6. Bookwalter, K.W. Grip strength norms for males. Res. Quart., 21:249-273, 1950.

7. Brozek, J. Changes in sensory, motor, and intellective function with age. Geriatrics, 6:221-226, 1951.

8. Bruce, S., Newton, D. & Woledge, R. Effect of age on voluntary force and cross-sectional area of human adductor pollicis muscle. Quart. J. of Exper. Physiology 74(3):359-362, 1989.

9. Brunnstrom, S. Clinical Kinesiology. Philadelphia: F.A. Davis Company, 1972.

10. Burke, W.E., Tuttle, W.W., Thompson, C.W., Janney, C.D. & Weber, R.J. The relation of grip strength and grip-strength endurance to age. J. of Appl. Phys., 5:628-630, 1953.

11. Campney, H.K. & Wehr, R.W. An interpretation of the strength differences associated with varying angles of pull. Res. Quart., 39:403-413, 1965.

12. Clarke, H.H. Toward a better understanding of strength. Phys. Fitness Res. Dig., President's Council on Physical Fitness and Sports, Series 3, No. 1, 1973.

13. Clarke, H.H., Bailey, T.L., & Shay, C.T. New objective strength tests of muscle groups by cable-tension methods. Res. Quart. 23:136-148, 1952.

14. DeVries, H.A. Physiology of Exercise for Physical Education and Athletics. Dubuque: William C. Brown Company Publishers, 1980.

15. Erimini, M. Aging changes in mammalian skeletal muscle. Gerontology, 22:301-316, 1976.

16. Everett, P.W. & Sill, F.D. The relationship of grip strength to stature, somatotype components, and anthropometrics of the hand. Res. Quart.. 23:161-166, 1952.

17. Frantzell, A. & Inglemark. B.E. Occurance and distribution of fat in human muscles at various age levels. Acta. Soc. Med. Ups. 56:59-87, 1951.

18. Grimby, G., Danneskiod-Samsoe, B., Hvid, K., & Saltin, B. Morphology and enzymatic capacity in arm and leg muscles in 78-81 year old men and women. Acta. Physiol. Scand. 115:125-134, 1982.

19. Grimby, G., Physical activity and effects of muscle training on elderly. Anals of Clinical Res., 20(1-2): 62-66, 1988.

20. Gutman, E., Hanzlikova, V. & Jakoubek, B. Changes in the neurovascular system during old age. Exp. Gerontol., 3:141-146, 1968.

21. Haffajee, D., Moritz, U., & Svantesson, G., Isometric knee extension strength as a function of joint angle, muscle length and motor unit activity. Acta. Orthop. Scandinav. 43:138-147, 1972.

22. Hettinger, T. Physiology of Strength. Springfield: Charles C. Thomas, 1961.

23. Hiebert, L.M. The relationship between field and laboratory strength tests for 60-75 year old senior citizens Unpublished Master's Thesis, University of Kansas, 1983.

24. Ikai, M. & Fukanaga, T. Int. Z. Angew. Physiol. Einschl. Arbeitsphysiol. 26:26.

25. Jette, M. & Cureton, T.K. Anthropometric and selected motor fitness measurements of men engaged in a long-term program of physical activity. Res. Quart. 47:666-671, 1976.

26. Knapik, J.J. & Ramon, M.U. Isokinetic and isometric torque relationships in the human body. Arch. Phys. Med. and Rehab 61:64-67, 1980.

27. Larsson, J., Grimby, G., & Karlsson, J. Muscle strength and speed of movement in relation to age and muscle morphology. J. of Appl. Phys., 46:451-456, 1979.

28. Lindahl, O., Movin, A., & Ringqvist, I. Knee extension: measurement of the isometric force in different positions of the knee joint. Acta. Orthop. Scandinav., 40:79-85, 1969.

29. Martin, E.G. & Rich, W.H. Muscular strength and muscular symmetry in human beings. Am. J. of Phys., 47:29-42, 1918.

30. Moffroid, M., Whipple, R., Hofkosh, J., Lowman, E., & Thistle, H. A study of isokinetic exercise. Phys. Ther.,49:735-346

31. Montoye, H.J. & Lamphiear, D.E. Grip and arm strength in males and females, age 10 to 69. Res. Quart., 48:109-120, 1977.

32. Morehouse, L. & Miller, A. Physiology of Exercise (6th ed.). Saint Louis: The C.V. Mosby Company, 1971.

33. Moudgil, R. & Karpovich, P.V. Duration of a maximal isometric muscular contraction. Res. Quart., 40:536-539, 1969.

34. Murray, M.P., Baldwin, J.M., Gardner, G.M., Sepic, S.B., and Downs, W.J. Maximum isometric knee flexor and extensor muscle contractions: normal patterns of torque versus time. Phys. Ther., 56:637-643, 1977.

35. Murray, M.P., Gardner, G.M., Mollinger, L.A., & Sepic, S.B. Strength of isometric and isokinetic contractions: knee muscles of men aged 20 to 86. Phys. Ther. 59:412-419, 1980.

36. Osness, W.H. Grip strength, hand steadiness reaction time and hand-eye coordination changes with age. Unpublished Report, March, 1990.

37. Osternig, L. Optimal isokinetic loads and velocities producing muscular power in human subjects. Arch. Phys. Med. Rehabil. 56:152-155, 1975.

38. Petrofsky, J.S. & Lind, A.R. Aging, isometric strength and endurance, and cardiovascular responses to static effort. J. of Appl. Phys., 38:91-95, 1975

39. Pierson, W.R. & O'Connell, E.R. Age, height, weight, and grip strength. Res. Quart., 33:439-443, 1972.

40. Rodahl, K & Horvath, S. Muscle as a Tissue. New York: McGraw-Hill book Company, Inc., 1972.

41. Rosentsweig, J. & Hinson, M.M. Comparison of isometric, isotonic, and isokinetic exercises by electromyography. Arch. Phys. Med. & Rehabil., 53:249-252, 1972.

42. Scudder, G.N. Torque curves produced at the knee during isometric and isokinetic exercise. Arch. Phys. Med. & Rehabil., 61:68-73, 1980.

43. Simonsen, E. Physical fitness and work capacity of older men. Geriatrics, 2:110-119, 1947.

44. Thorstensson, A., Grimby, G., & Karlsson, J. Force-velocity relations and fiber composition in human knee extensor muscles. J. of Appl. Phys., 40:12-16, 1977.

45. Tinkle, W.F. & Montoye, H.J. Relationship between grip strength and achievement in physical education among college men. Res. Quart., 32:238-243, 1961.

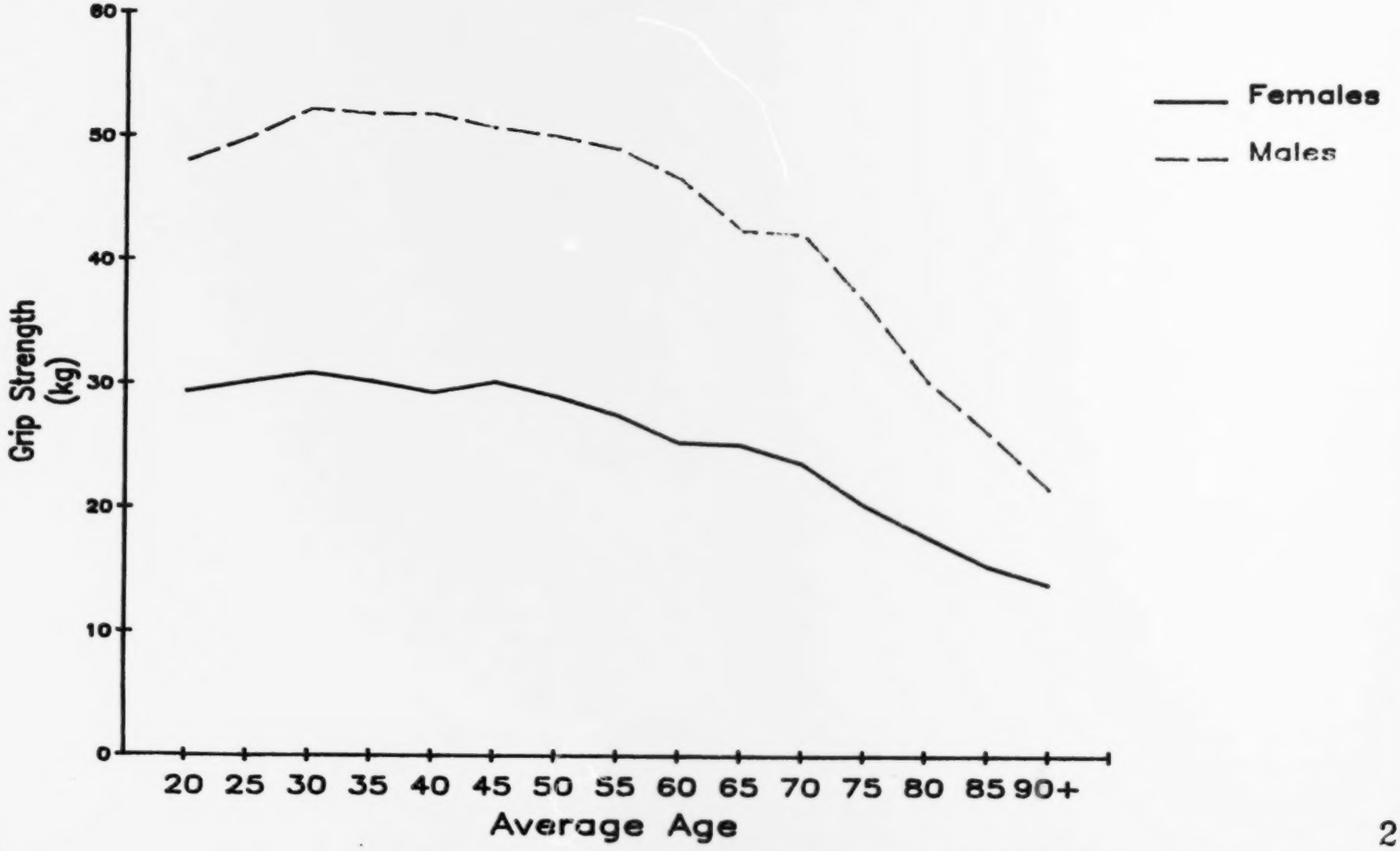
46. Vandervoort, A. & McComas, A., Contractile changes in opposing muscles of the human ankle joint with aging, J. of Applied Phys. 61(1):361-367, 1986.

47. Wendler, A.J., An analytical study of strength tests using the universal dynamometer. Res. Quart., 6:81-85, 1935.

48. Wessel, J.A. & Van Huss, W.D. The influence of physical activity and age on exercise adaptation of women aged 20-69 years. J. Sports Med., 9:173-180, 1969.

Figure 1

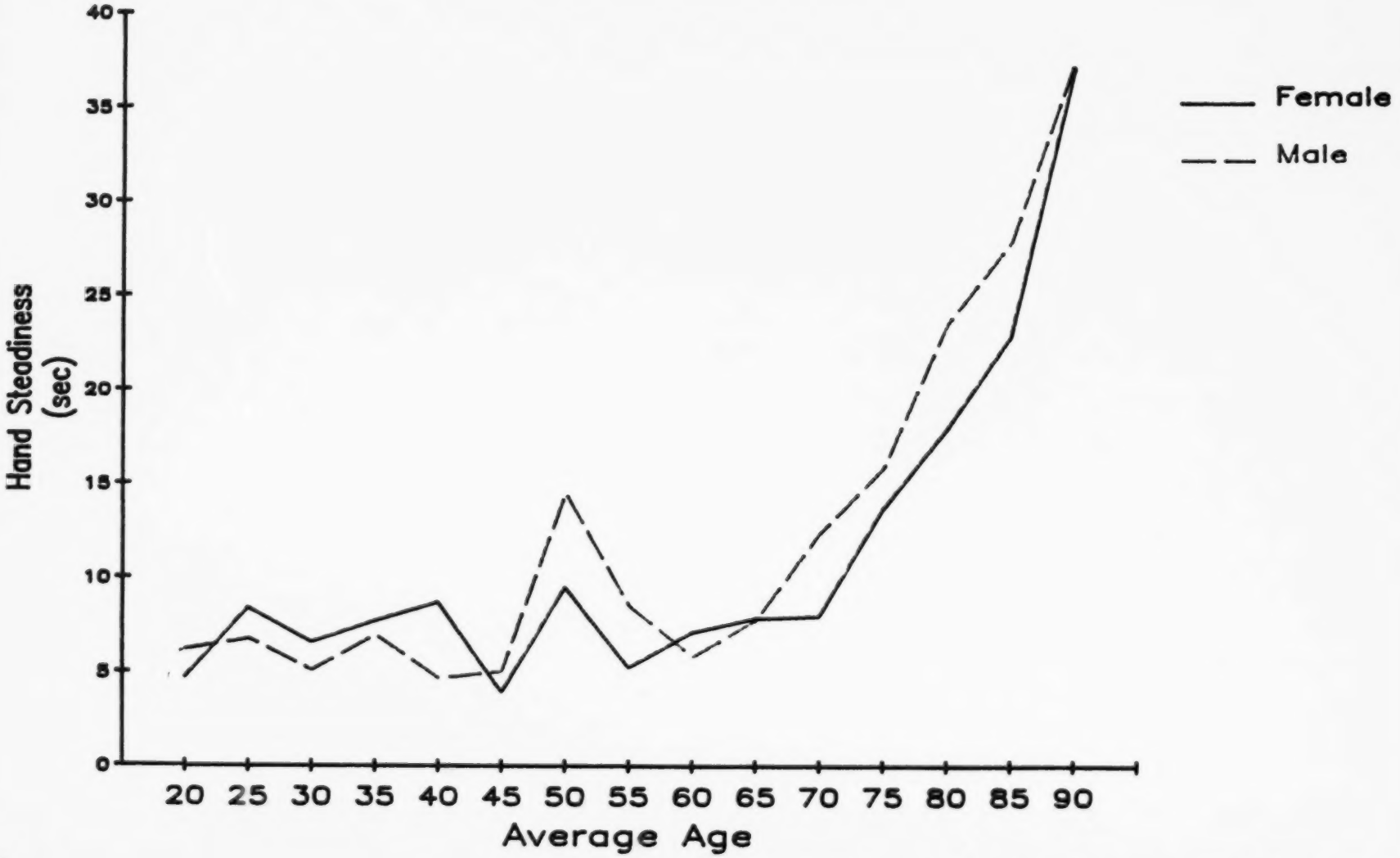
The Average Grip Strength Scores for Males and Females Tested at the University of Kansas Fitness Clinic Up to Fall 1989



Mean scores were calculated from 5 year intervals.

Figure 2

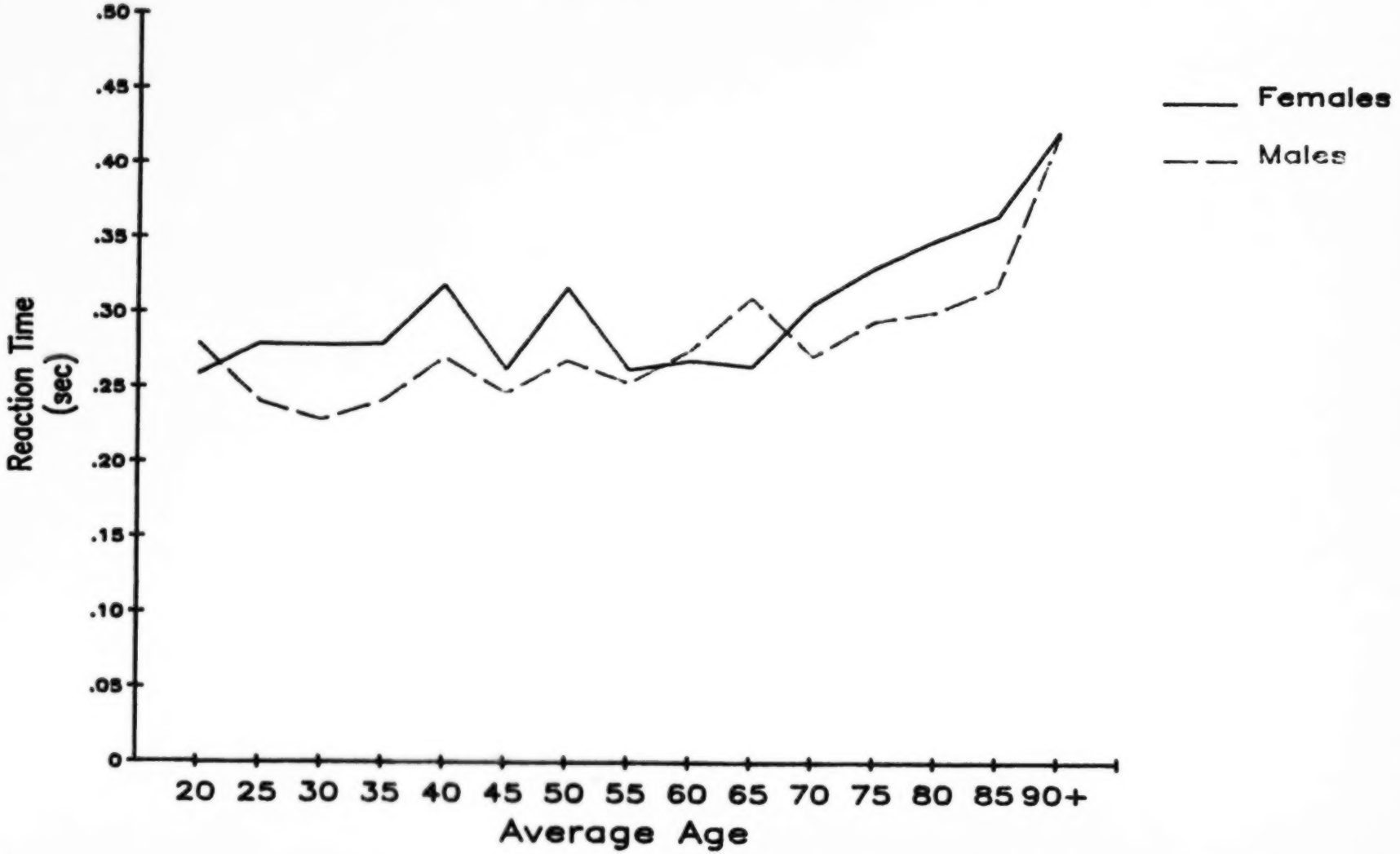
The Average Hand Steadiness Scores for Males and Females Tested at the University of Kansas Fitness Clinic Up to Fall 1989



Mean scores were calculated from 5 year intervals.

Figure 3

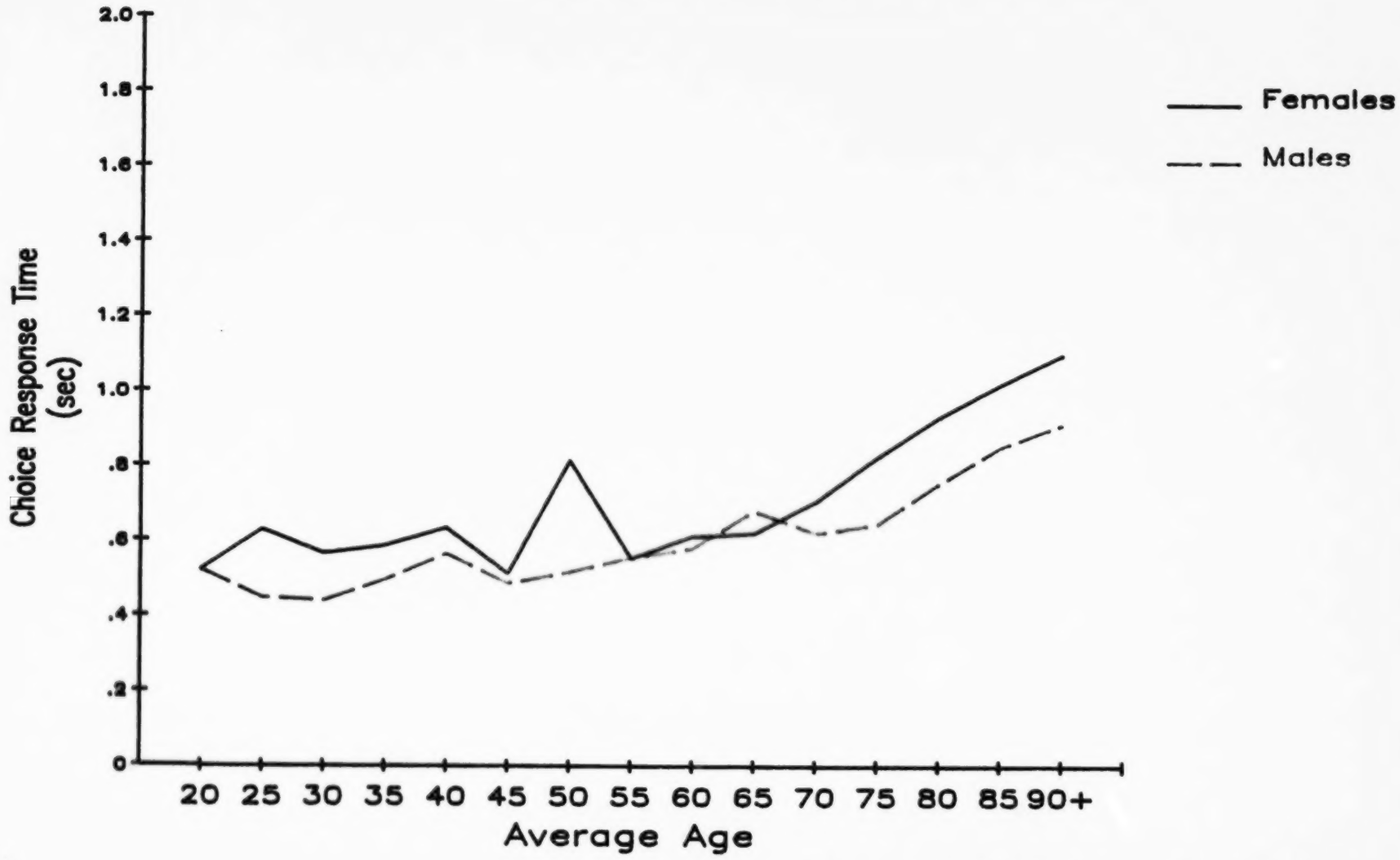
The Average Reaction Time Scores for Males and Females Tested at the University of Kansas Fitness Clinic Up to Fall 1989



Mean scores were calculated from 5 year intervals.

Figure 4

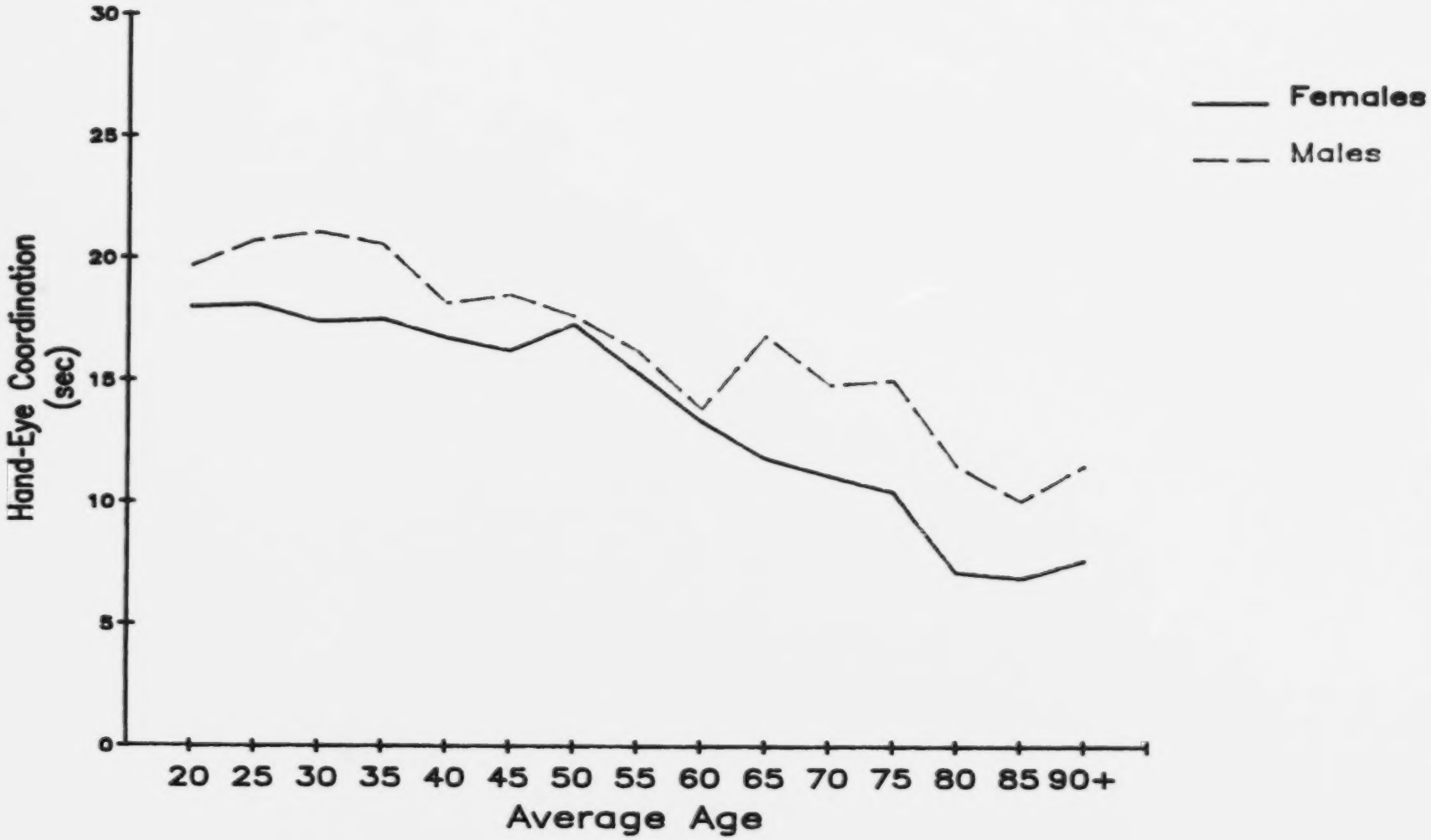
The Average Choice Response Scores for Males and Females Tested at the University of Kansas Fitness Clinic Up to Fall 1989



Mean scores were calculated from 5 year intervals.

Figure 5

The Average Hand-Eye Coordination Scores for Males and Females Tested at the University of Kansas Fitness Clinic Up to Fall 1989



Mean scores were calculated from 5 year intervals.

Table I

Correlation Coefficients of Field Tests vs. Arm, Leg, and Total Isokinetic Laboratory Tests
(N = 30)

Field Test	Total Kinetic Score r	Total Leg Score r	Total Arm Score r
Shoulder Flexion	.82**	.80**	.81**
Elbow Flexion	.84**	.79**	.90**
Hand Grip	.86**	.80**	.91**
Hip Flexion	.72**	.74**	.64**
Knee Extension	.71**	.71**	.65**
Total Field Score	.90**	.87**	.90**

** $p \leq .01$

Table II

Strength Tests Used as Predictors of
Total Body Isokinetic Strength
(N = 30)

Number of Predictors	Coefficient of Determination	Field Tests
3	.83	Hand Grip Hip Flex Knee Ext
2	.82	Hand Grip Hip Flex
2	.82	Hand Grip Knee Ext
2	.57	Hip Foex (Flex) Knee Ext
1	.73	Hand Grip
1	.52	Hip Flex
1	.50	Knee Ext

Table III

Strength Tests Used as Predictors of
Total Arm Isokinetic Strength
(N = 30)

Number of Predictors	Coefficient of Determination	Field Tests
3	.86	Hand Grip Hip Flex Knee Ext
2	.86	Hand Grip Knee Ext
2	.85	Hand Grip Hip Flex
2	.46	Hip Flex Knee Ext
1	.83	Hand Grip
1	.42	Knee Ext
1	.41	Hip Ext

Table IV

Strength Tests Used as Predictors of
Total Leg Isokinetic Strength
(N = 30)

Number of Predictors	Coefficient of Determination	Field Tests
3	.78	Hand Grip Hip Flex Knee Ext
2	.77	Hand Grip Hip Flex
2	.75	Hand Grip Knee Ext
2	.58	Hip Flex Knee Ext
1	.65	Hand Grip
1	.54	Hip Flex
1	.51	Knee Ext